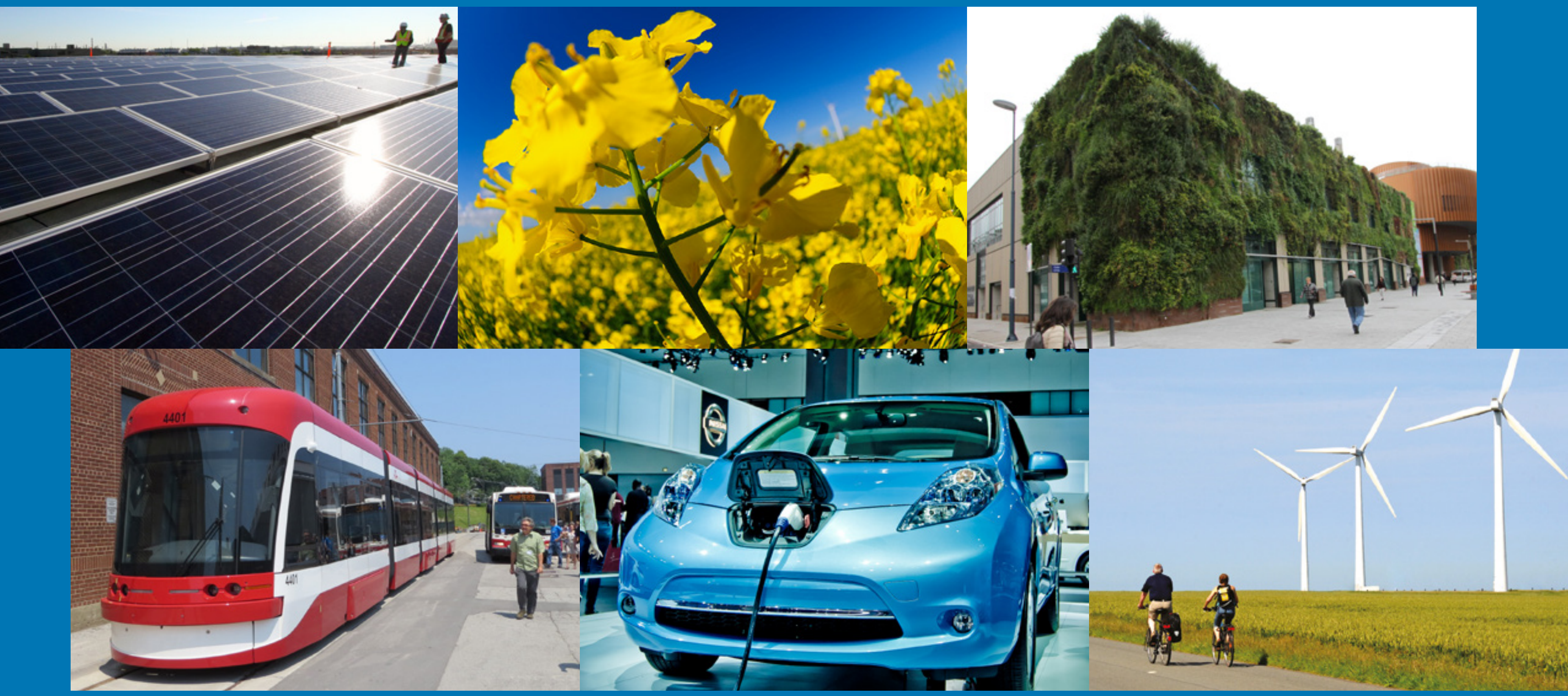
CANADA'S CHALLENGE & OPPORTUNITY

Transformations for major reductions in GHG emissions



Executive summary

PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

Trottier Energy Futures Project Partners

April 2016

This project was made possible
through the generous financial support
of the Trottier Family Foundation.

Fondation familiale Trottier Family Foundation

The Canadian Academy of Engineering / L'Académie canadienne du génie
Leadership in Engineering Advice for Canada / Chef de file en matière d'expertise-conseil en génie pour le Canada

The Canadian Academy of Engineering
300 – 55 Metcalfe Street
Ottawa, Ontario, K1P 6L5, Canada
Phone: (613) 235-9056
www.cae-acg.ca

David Suzuki Foundation
SOLUTIONS ARE IN OUR NATURE

David Suzuki Foundation
219 – 2211 West 4th Avenue
Vancouver, BC V6K 4S2, Canada
Phone 604-732-4228
or toll free at 1-800-453-1533
www.davidsuzuki.ca

Foreword

The Intergovernmental Panel on Climate Change (IPCC) 2014 Synthesis Report states that *"substantial [greenhouse gas] emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term, and contribute to climate-resilient pathways for sustainable development."*

The report suggests that there are multiple transformational pathways to attaining the goal of significantly reducing greenhouse gas (GHG) emissions.

The challenge of significantly reducing GHGs in Canada is complex, involving a number of combinations of possible pathways. To explore ways of achieving deep reductions, the Trottier Energy Futures Project is defined by the goal of reducing GHG emissions by 80 per cent from 1990 levels by the year 2050, and with consideration of reducing GHG emissions by 100 per cent or more by the end of the century. The Project employs a systems analysis approach by specifying a target reduction for GHG emissions from combustion sources. It uses two models to optimize pathways to attaining the target at minimum cost, for a variety of scenarios that define alternative futures. The approach defines the least-expensive ways forward and sets the stage for informed conversations that will increase understanding of GHG reduction options open to Canada, and the steps that will lead to early reductions.

The pathways outlined could be more economically attractive when the co-benefits are considered, such as improved public health, traffic management, and infrastructure life-cycle costs. An economic assessment of co-benefits and risks for each scenario was beyond the scope of this research.

Finally, this study is a collaborative effort by three organizations. We may have differing opinions about some of the pathways outlined, but we are in strong agreement that it is important to publish the results of the study in order to stimulate an informed discussion about how to meet internationally defined GHG reduction targets. We need to have those conversations as quickly as possible in order to create the future we desire.

Trottier Family Foundation

The Canadian Academy of Engineering

David Suzuki Foundation

Acknowledgements

The initiative and funding for the Trottier Energy Futures Project (TEFP) came from Lorne Trottier, through the Trottier Family Foundation. Lorne Trottier is an engineer, an entrepreneur, and a philanthropist. He is a Member of the Order of Canada and a Fellow of the Canadian Academy of Engineering. He is a proud Canadian and is committed, with his family, to being a catalyst for Canada to assume a leadership role in addressing the serious climate-change challenge in Canada and around the world.

The project was jointly sponsored by the Canadian Academy of Engineering (CAE) and the David Suzuki Foundation (DSF). Overall direction for the project was provided by a three-person Project Board, including John Leggat (CAE), Peter Robinson (DSF), and Lorne Trottier.

The Project Team included Oskar Sigvaldason, Project Manager and President, SCMS Global; Kathleen Vaillancourt, President, ESMIA Consultants; Michael Hoffman, President, whatIf?; Mara Kerry, Director of Science and Policy, DSF; Ian Bruce, Science and Policy Manager, DSF; and Kevin Goheen, Executive Director, CAE. Other principal contributors included Professor Warren Mabee, Queens University; Professor Emeritus Robert Evans, University of British Columbia; and Alex Boston, President, Boston Consulting. Professor Olivier Bahn, École des Hautes Études Commerciales de Montréal, was Advisor to ESMIA Consultants. Professor Patrick Condon, University of British Columbia, was Advisor to Boston Consulting. Valuable support was provided by Erik Frenette (ESMIA), and by Bas Straatman and Shona Weldon (whatIf?). A four-person Expert Review Panel provided quality assurance for the project. Members of the panel included Professor Andre Plourde, energy economist and Dean of Public Affairs, Carleton University; John Leggat, former Assistant Deputy Minister (Science & Technology), Department of National Defence; Ken Ogilvie, environmental policy consultant to governments, business and environmental organizations; and Professor Miguel Anjos, Canada Research Chair in Discrete Nonlinear Optimization, Polytechnique Montréal and GERAD.

During the course of the project, discussions were held and reviews were conducted with selected representatives from government, industry, non-profit organizations, and universities across Canada, including the National Energy Board, Natural Resources Canada (including the Canadian Forest Service), Environment Canada, Statistics Canada, Canadian Electricity Association, Canadian Association of Petroleum Producers, and Alberta Innovates — Energy and Environment Solutions.

Following preparation of the Draft Report, reviews were carried out by CAE and DSF. For CAE, reviews were done by a committee chaired by Professor Douglas Ruth that included Sara Jane Snook, Eddy Isaacs and Professor Aniruddha Gole. Reviews were conducted by Miles Richardson and Professor Peter Victor, Directors of the Board of DSF, and by Peter Robinson and Gideon Forman of DSF.

Executive summary

The Trottier Energy Futures Project is a comprehensive engineering analysis of Canada's future energy systems, with the goal of achieving an 80 per cent reduction in GHGs by 2050, relative to 1990 levels.

The study is based on two detailed quantitative models for combustion emissions that have been calibrated using historical data.

The models calculated projected GHG emissions in Canada from combustion to 2050 using a variety of scenarios, as well as a defined set of energy technologies. The models also calculated "marginal costs" for the projected energy system transformations in the form of equivalent carbon prices over time for each scenario.

For most scenarios, the approach was based on currently deployed technologies with plausible extrapolations for future improvements and cost reductions. Furthermore, the simulations assumed a centralized power generation and distribution system similar to the dominant paradigm of today.

Several potential technologies that could make contributions to reducing GHG emissions were not explored due to insufficient data.

The main value of this project is that it shows what is possible with current technology. While the precision of the predicted emission levels is limited by the accuracy of the models and the underlying assumptions, an analytical approach involving several scenarios has produced robust results that identify promising pathways and options for deep GHG reductions in Canada.

Findings

The most aggressive scenario occurs with lower global fossil-fuel demand and correspondingly lower production and export by Canada. This scenario results in a 70 per cent reduction in combustion emissions, from 425 million tonnes (MT) in 1990 to 128 MT in 2050. Very large increases in electricity and biomass/biofuels use occur as a result.

The aggressive scenario includes proven technologies, such as hydro, nuclear and wind power, as well as technologies that are not yet commercially available, such as second-generation biofuels, coal-fired thermal power plants retrofitted with carbon capture and storage, and bioenergy production with carbon capture and storage. In addition, the model selects 122 gigawatts of new large-scale hydro power. Significant reductions in emissions occur in all five end-use sectors, and rapid decarbonization of electricity supply also occurs (by 2030). In 2050, the three sectors still producing significant GHG emissions include transportation, industry, and fossil-fuel supply.

A qualitative assessment was made of the potential for reducing GHG emissions from non-combustion sources. The most optimistic projection for the combination of combustion and non-combustion sources indicates GHG emissions of 360 MT in 2050, which is greater than the goal of 118 MT. Net-negative emissions may be required to close the gap.

The adoption of significant energy conservation and efficiency measures offers low-cost options (including several at negative cost) for reducing GHG emissions. For example, energy conservation measures eliminate a large proportion of the future demand for space heating in the commercial sector — as much as 60 per cent in 2050, depending on the scenario (and as much as 40 per cent in the residential sector).

The modeling derives marginal cost per tonne of CO_2-equivalent for imposed GHG emission limits. These costs depend on the scenario analyzed but generally exceed $100 per tonne of CO_2-equivalent in the early years for all scenarios and increase over time to several hundred dollars per tonne (2011 dollars).

Priorities for action

The project highlights the changes in Canada's existing and future energy infrastructure that will be needed in order to achieve deep GHG reductions. Promising pathways to a low-carbon future are identified. And while future technologies and other innovations may lead to new pathways or result in lower costs than those shown by the analysis, the project demonstrates that substantial progress can be made by 2030 using currently available systems to reduce GHG emissions. Key areas include significantly increasing the supply of electricity and biomass/biofuels in order to displace fossil fuels in all five end-use sectors, decarbonizing electricity production by switching to non-emitting sources, enabling transfers of electricity between provinces and territories, and implementing a comprehensive program of energy conservation and efficiency measures. In addition, as several provinces and the federal government have already committed to implementing carbon pricing, a national climate strategy, along with regulations and incentives that support innovative GHG-reduction technologies and initiatives, may be within reach.

Challenges

As the project progressed, a number of significant challenges became apparent. If these challenges remain unaddressed, achieving deep reductions in GHG emissions will prove exceedingly difficult. Further investigation and assessment are needed in the following areas:

- The development and deployment of second-generation biofuels, especially for use in heavy freight and rail transport
- In-depth analysis of options for reducing GHG emissions from industrial combustion and non-combustion sources
- A comprehensive program of data collection and analysis to assess the full magnitude of the fugitive emissions problem and to identify mitigation approaches
- Accelerated research on ways to reduce GHG emissions from oil and natural gas production, upgrading, and refining, including fuel switching and process changes

- Further work on the extent to which improved urban form can reduce overall infrastructure costs and related GHG emissions, and on promising GHG reduction approaches, such as public transit, co-generation, distributed generation, district heating, waste to energy, and local energy storage

- Research on ways to achieve net-negative GHG emissions, including biomass electricity generation with carbon capture and storage, increased use of wood products for carbon retention in buildings, and carbon sequestration through afforestation and reforestation

- Recognition that consultations with decision makers, communities, and First Nations will need to occur for the envisioned pathways to come to pass

Concluding comments

The Trottier Energy Futures Project provides a rigorous comprehensive analysis of the potential for deep reductions in Canadian GHG emissions. It identifies promising and implementable low-GHG reductions options and pathways. The deep reduction pathways are highly challenging and involve extensive energy conservation and efficiency measures, major restructuring of our energy infrastructure, deployment of promising but not yet commercially available technologies, and fundamental changes in how people think about and use energy.

The energy options that must be implemented to achieve deep GHG reductions (reduced use of fossil fuels for end uses, decarbonization of the electricity supply, increasing the use of biomass/biofuels) all result in developments between now and 2050 that present formidable challenges.

The results from the project cast considerable doubt about the timely availability of technology and associated infrastructure; however, the greatest challenge may not be technical or even economic as much as political and social/cultural. Deep GHG reductions will affect all Canadians and will therefore necessarily involve changes in lifestyle. The results also speak to a requirement for carbon pricing and supporting regulation. The accomplishment of the societal transformations involved in reducing GHG emissions by 80 per cent or more will require leadership from all sectors of society, and will require Canadians to develop a widely shared vision of low-carbon lifestyles and energy systems.

The results of the project can be used to inform national dialogue on strategies needed to achieve deep emission reductions. Our future will be determined by the choices we make today about energy use and GHG emissions. The open and frank discussion this project engenders can lead to meaningful progress and build confidence that Canada can work internally and with other nations to restore the health and resiliency of the planet's climate system.